

TRACKING THE EVOLUTION OF ELECTRIC VEHICLES AND NEW MOBILITY TECHNOLOGY

Yan (Joann) Zhou (PI, yzhou@anl.gov), David Gohlke, Jarod Kelly, Mike Duoba, Luke Rush, and Simeon Iliev; Argonne National Laboratory

Vehicle Technologies Office 2021 Annual Merit Review, VAN032

PROJECT OVERVIEW

Synthesize and improve upon data for electrification and mobility technologies to evaluate the impacts of these new technologies.

The project includes the following tasks:

- Electric-drive (E-drive) vehicle sales and announcement tracking
- New mobility technologies tracking
- PEV national and regional impact assessment
- E-drive Vehicle and Battery Supply Chain Tracking
- High fidelity Plug-in electric vehicle (PEV) technologies characterization
- Sensors for highly automated vehicles (FY20-21 only)

The project provides quality data and information on electrification and new mobility technologies to the VTO Analysis Program and external researchers. Deliverables include monthly and annual public facing reports. Selected data is published on the Argonne website.

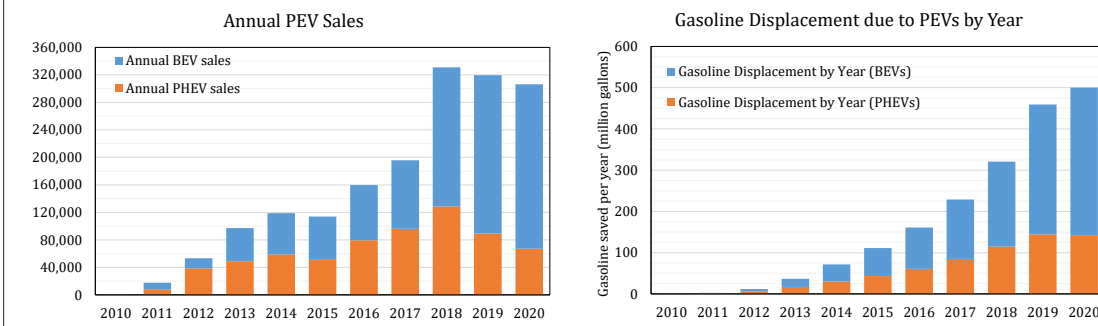
TASK OBJECTIVES

- Electric-drive vehicle sales and announcement tracking:** Collect monthly PEV, hybrid electric vehicle (HEV) and fuel-cell vehicle (FCEV) sales by make and model, and summarize the market and technology trends. This task also tracks announcements made by industry on projected deployment of PEV technologies.
- PEV national and regional impact assessment:** Quantify the national impact of PEV adoption on an annual basis. Metrics include aggregate electricity consumption and gasoline consumption reduction, and average vehicle performance. Update this report on an annual basis, thereby showing the evolution of PEV characteristics.
- E-drive vehicle li-ion battery supply chain tracking:** Summarize historical and future li-ion battery cell and pack production by manufacturer and by vehicle make/model for light-duty E-drive vehicles sold and manufactured in the U.S. This task tracks industry announcements on future plans and production targets.
- New mobility technologies tracking:** Summarize mobility data availability and trip trend by region and mobility type. Shared mobility types include bike, scooter and ride-sharing provided by transportation network companies (TNC). This task tracks how shared mobility usage evolves and varies by household income and the number of vehicles per household.
- Sensors for highly automated vehicles:** Provide a comprehensive overview of current and emerging AV hardware, creating the foundation for a range of further technology development and energy impact assessment research. This task includes an in-depth assessment of current AV hardware and the agencies/companies engaged in the space to better understand current and upcoming sensor and processing system capabilities.
- High fidelity PEV technologies characterization:** Seek insights into specific contributors to PEV efficiency (or lack thereof). This task separates and quantifies the individual contributions of 1) powertrain efficiency, 2) vehicle efficiency and, for some vehicles, 3) charger efficiency using detailed energy information from chassis dynamometer testing.

PEV SALES TRACKING AND IMPACT ASSESSMENT

Tracking key metrics related to use of plug-in electric vehicles in U.S.

- Over 300,000 PEV sold last year; over 500 million gallons of gasoline offset by PEVs in 2020

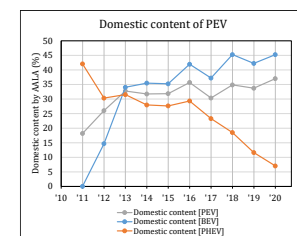


ELECTRIC VEHICLE MANUFACTURING SUPPLY CHAINS

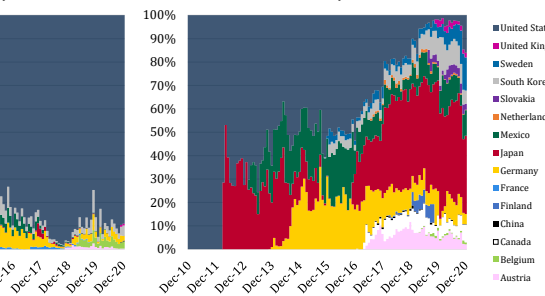
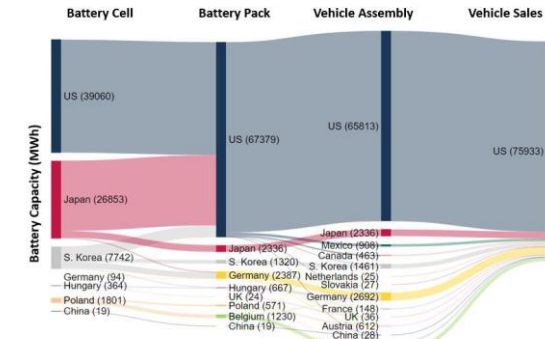
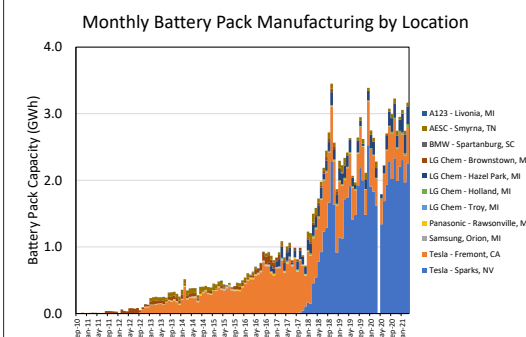
Vehicles & batteries manufactured and sold in the U.S.

- The majority of PEVs sold in the U.S. have been assembled in the U.S., using battery packs built in the U.S.
 - Majority of battery cells have come from U.S., Japan, and South Korea
 - Other manufacturing locations include Germany and Belgium (vehicles & packs), Poland and Hungary (cells), and Mexico and Canada (vehicles)

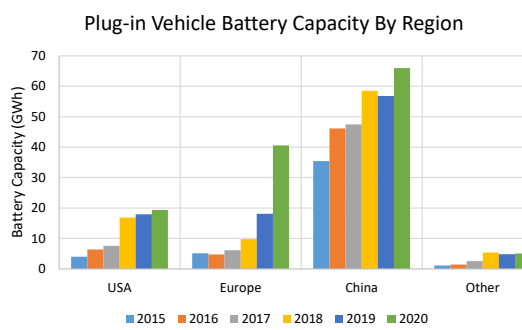
- While most BEV sold in the U.S. have been made here since 2013, more PHEV are being assembled abroad



- Majority of battery packs in the U.S. assembled in either Fremont, CA or Sparks, NV (Tesla Gigafactory)



- United States is currently the #3 global market for lithium-ion batteries in PEVs worldwide, after China and Europe

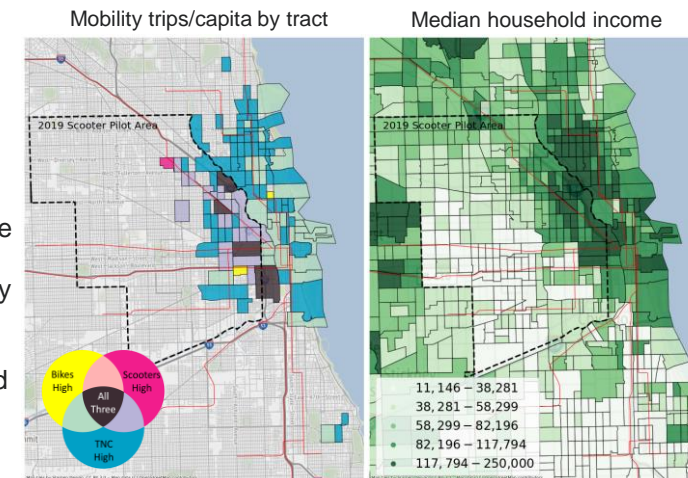


NEW MOBILITY TECHNOLOGIES TRACKING

How shared mobility usage evolves and varies by demographic factors

- Evaluated shared mobility technology usage in context of household income

- The left figure shows census tracts that are above the 90th percentile in trips per capita by scooters, bikes, TNCs, or some combination of the three

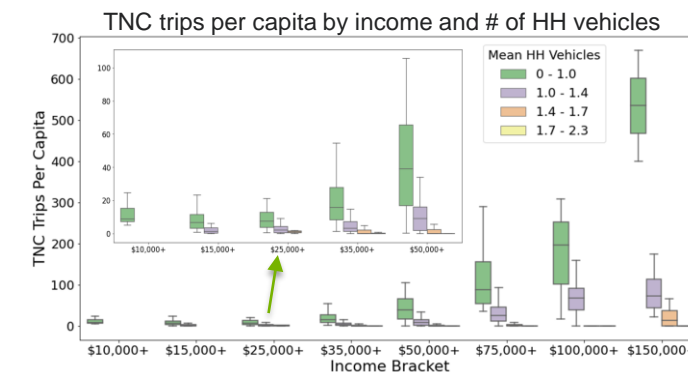


- Tracts with high mobility usage are generally correlated across all three mobility types and are highly correlated with high income

- Analyzed how shared mobility usage varies by household income and the number of vehicles per household.

- Tracts with higher household income and fewer household vehicles tend to have higher TNC usage per capita

- Bikeshare and scooter share usage show a similar trend

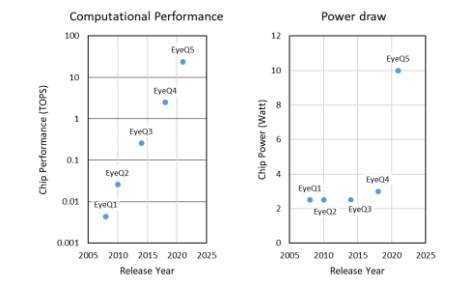


Results are similar for bike share and scooter share

AUTOMATED VEHICLE SENSING AND PROCESSING

Sensors that are necessary for highly automated vehicles and their impact on vehicle design

- Key sensor technologies:
 - LIDAR – High resolution, medium to long range, and very expensive
 - Radar – Long range, suited for measuring angle/velocity, cheaper than comparable LIDAR
 - Camera – Ubiquitous and cheap, required for reading color and text
 - Ultrasonic – Small and cheap, utilizes sound for close range sensing
- Sensors have grown exponentially in performance and efficiency, but power draw has gradually increased over time
- GPU sensor capability growing quickly, may prevent growth of ASIC market
- Power draw from computation may affect some OEM choices for powertrain selection (e.g. HEV vs ICEV vs BEV).
- Testing and validation viewed as a useful space for DOE investment and R&D



PEV EFFICIENCY CHARACTERIZATION

Dig into PEV efficiency data to reveal new insights:

In-Depth Vehicle Efficiency

- Rolling resistance losses
- Aerodynamic losses
- Total cycle losses

Powertrain Efficiency Analysis

- City vs Highway Efficiency
- Tracking changes over model years
- 4WD vs 2WD (4WD is more efficient)
- Analysis of battery vs cycle energy vs range
- Outliers noted

Charger + Battery Efficiency Calculations

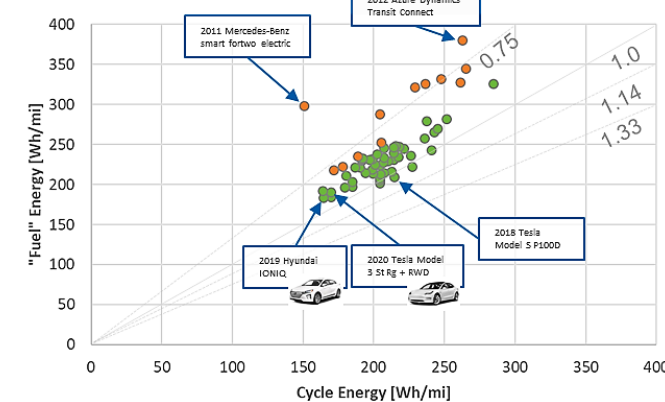
- Most OEMs 85-89%, some are much higher showing potential missing efficiency
- Database of results:
 - 2012 to 2020 EVs
 - Sortable, filterable for additional analyses

Deliverable

Efficiency?



VS



CONCLUSIONS

- PEVs remain approximately 2% of U.S. market
- Most BEV sold in the United States are manufactured in the U.S., while most PHEV are imported
- New mobility options are growing in cities nationwide, but their use is not distributed across all demographic segments
- PEV Efficiency Analysis: Most OEMs are not using best efficiency chargers (opportunity!); most efficient PEVs are 4WD, opposite of conventional cars.
- Automated vehicle sensors can have non-negligible power draw; as capabilities grow, power draw also tends to grow

PUBLICATIONS

- "[Lithium-Ion Battery Supply Chain for E-Drive Vehicles in the United States: 2010–2020.](#)" Yan Zhou, David Gohlke, Luke Rush, Jarod Kelly, and Qiang Dai. Argonne National Laboratory Technical Report ANL/ESD-21/3 (2021).
- "[Assessment of Light-Duty Plug-In Electric Vehicles in the United States, 2010–2020.](#)" David Gohlke and Yan Zhou. Argonne National Laboratory Technical Report ANL/ESD-21/2 (2021).

ACKNOWLEDGEMENTS

The authors would like to thank David Howell, Jacob Ward, Steven Boyd of the VTO for the continued support of this project and constructive comments. The authors thank Stacy Davis and Robert Boundy of Oak Ridge National Lab for providing sales data.

Any proposed future work is subject to change based on funding levels.

This presentation does not contain any proprietary, confidential, or otherwise restricted information